

## **Report for 2005MT70B: STUDENT FELLOWSHIP: On the dynamics and production of CO<sub>2</sub> in a forested watershed**

### **Publications**

- There are no reported publications resulting from this project.

### **Report Follows**

June 7<sup>th</sup>, 2006

**Susan Higgins, Assistant Director for Outreach  
Montana Water Center  
103 Huffman Hall  
Montana State University  
Bozeman, MT 59717**

Re: Final Fellowship Report.

Dear Ms. Higgins,

As requested in your recent email, I submit to you the final report of activities I have accomplished during the 2005-2006 year. My dissertation research is titled: **“On the dynamics and production of CO<sub>2</sub> in a forested watershed.”** Feel free to contact me if you have further questions.

1. Abstract (to include your contact information).

The uncertainties embedded in current estimates of net ecosystem CO<sub>2</sub> exchange (NEE) are well acknowledged. More than two-thirds of total terrestrial C is stored below ground and exchanged to the atmosphere through plant and microbial activity, but the mechanisms of such exchange are not well understood. We investigated the variability of the environmental factors that control CO<sub>2</sub> production to understand the heterogeneity of soil CO<sub>2</sub> concentration and efflux at the watershed scale. We present measurements of CO<sub>2</sub> concentrations and flux over one year in mountainous, complex terrain of the 550-ha Stringer Creek watershed located in the Little Belt Mountains of Central Montana. Our results showed that the interaction of soil moisture and soil temperature plays a major role in controlling CO<sub>2</sub> production and efflux across topographic positions. High temporal resolution measurements showed two main trends in the variability of soil CO<sub>2</sub>: short-term (daily) variability controlled mainly by soil temperature, and long-term variability controlled by soil moisture. Long-term soil CO<sub>2</sub> concentration showed similar trends at other sites across the watershed. At upland sites, soil CO<sub>2</sub> concentrations reached their maximum after snowmelt and decreased thereafter. At lowland sites, soil CO<sub>2</sub> concentrations did not peak until the late summer. Similarly, dry upland areas showed a greater relative increase in soil CO<sub>2</sub> concentrations after rewetting events than wet lowland areas. We seek to assess the role of topography in controlling soil temperature, soil moisture and soil nutrient status to measure and model CO<sub>2</sub> production and efflux at the watershed scale. Our results are the first to show watershed-scale concentrations and fluxes of CO<sub>2</sub> over time.

Riveros, Diego A. Department of Land Resources and Environmental Sciences. Montana State University. 334 Leon Johnson Hall, Bozeman MT, 59717.  
[driveros@montana.edu](mailto:driveros@montana.edu). 406-994-5705.

Collaborators:

Pacific, Vince. Montana State University. 334 Leon Johnson Hall, Bozeman MT 59717.

McGlynn, Brian. Montana State University. 334 Leon Johnson Hall, Bozeman MT 59717.

Welsch, Daniel. Department of Geography. Frostburg State University, Frostburg, MD.

Epstein, Howard. Department of Environmental Sciences. University of Virginia,  
Charlottesville, VA.

## 2. Research Accomplishments

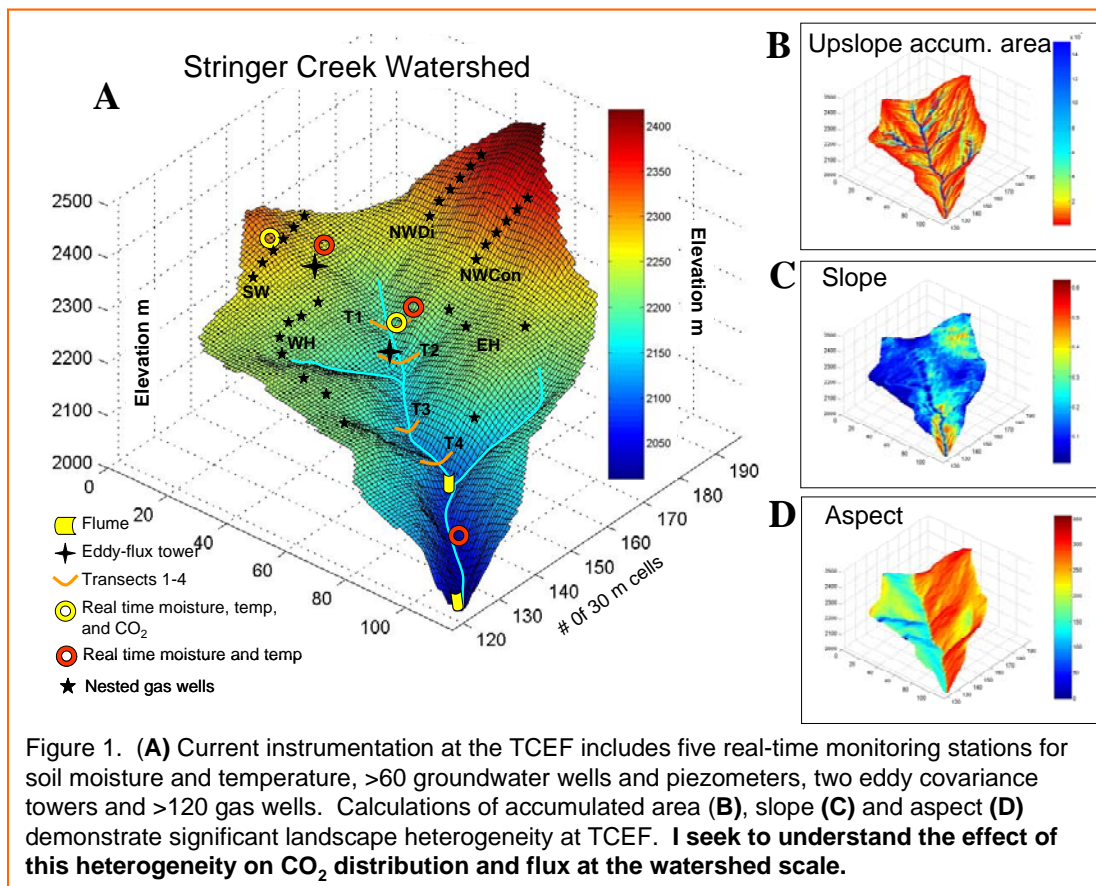


Figure 1 summarizes the instrumentation that went into the Tenderfoot Creek Experimental Forest. I installed a network of 120+ gas wells at two different depths (20 and 50 cm) in the soil semi-distributed across the watershed. The purpose of this installation was to capture the range of variability in soil moisture, soil temperature, aspect, upslope accumulated area, and topographic index, across topographic gradients and see how those variables control CO<sub>2</sub> production and efflux from the soil. We are still performing long-term monitoring of CO<sub>2</sub> concentration in these gas wells across the watershed, as well as surface efflux.

### 3. Conclusions

Our results indicate that the effects of soil moisture and vegetation cover are responsible for differences in soil CO<sub>2</sub> evolution patterns. Soil CO<sub>2</sub> evolution in wetter low areas reflects photosynthetic activity better than in uplands. This means that there is a greater contribution by root respiration in riparian areas and that microbial activity is also more dependent on root exudate dynamics in the riparian areas of the watershed.

Short-term variability in soil CO<sub>2</sub> concentrations is controlled by soil temperature, whereas long-term variability is controlled by soil moisture. However, the interaction of both of these variables controls CO<sub>2</sub> production and efflux across topographic gradients. Once soil moisture is no longer a control, soil temperature becomes the dominant control.

Contrary to previous research, CO<sub>2</sub> diffusivity may not be significantly affected by increases of soil moisture in drier, upland areas. Therefore, generalizations from single point-scale measurements may be misleading. Instead such measurements should be conducted across the full range of environmental conditions. Our work shows that increases in soil moisture can increase CO<sub>2</sub> flux from soils in moisture-stressed soils. These findings have significant implications for model parameterization and modeling of soil respiration forcing factors at the watershed scale.

The integration of multiple point scale soil respiration studies is necessary to understand net ecosystem exchange of CO<sub>2</sub> at the catchment scale due to landscape heterogeneity. Our approach is unique as it directly addresses the variability in CO<sub>2</sub> generation and efflux at the catchment scale and focuses on the controls of soil respiration across environmental gradients.